Grade 6 Science
Achievement Testing Program

Provincial Report

December, 1982

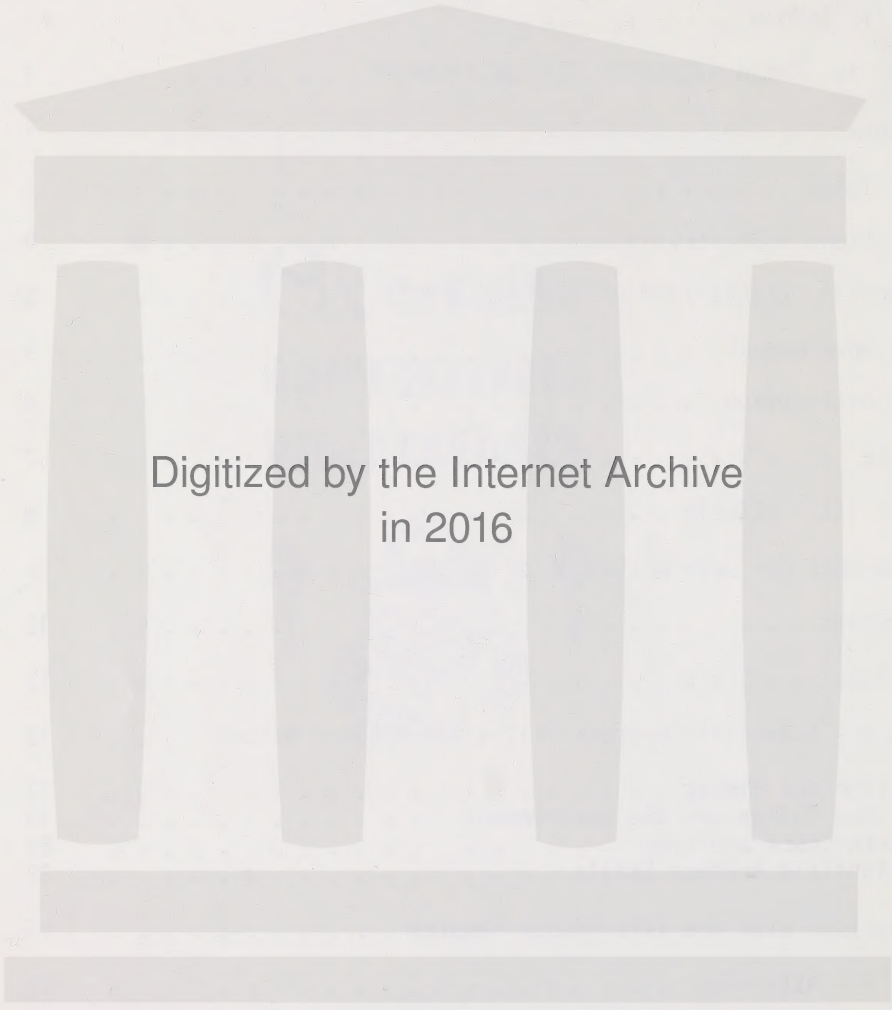
Distribution:

- Officials of Alberta Education
- School Principals
- Superintendents of Schools
- The Alberta Teachers' Association
- Alberta School Trustees' Association
- General Public upon Request

Alberta
EDUCATION

TABLE OF CONTENTS

	Page
LIST OF TABLES	iii
LIST OF FIGURES	v
ACKNOWLEDGMENTS	vii
INTRODUCTION	ix
EXECUTIVE SUMMARY	xi
Chapter I: THE ACHIEVEMENT TESTING PROGRAM	1
Purpose	1
1982 Tests	1
Exemptions from Testing	2
Chapter II: DESCRIPTION OF TEST AND SAMPLE	3
Test Development	3
Test Description	4
Sample	7
Chapter III: RESULTS	9
Guidelines for Interpretation of Results	9
Absentees	12
Cautions	13
Part A - Scientific Process Skills and Subject Matter	13
Matter and Energy	17
Living Things and the Environment	19
Earth-Space and Time	20
Scientific Process Skills	22
Comparison with the 1978 MACOSA Results	25
Part B - Attitudes	25
Part C - Psychomotor Skills	28
Concluding Observations	30
Appendix - PSYCHOMOTOR SKILLS QUESTIONNAIRE	31



LIST OF TABLES

Page

Table 1: Test Question Distribution for Part A 6

Table 2: Provincial Averages for Subtests in Part A 14

Table 3: Student Responses to Part B 26

Table 4: Availability of Equipment 28

Table 5: Psychomotor Skills Questionnaire 32

LIST OF FIGURES

Page

Figure 1: Averages for Total Test, Scientific Process Skills, and Subject Matter 16

Figure 2: Averages for Subject-Matter Content Areas 16

Figure 3: Student Responses to Part B 27

Figure 4: Intervals Containing at Least 70% of the Teacher Responses 29

ACKNOWLEDGMENTS

The successful administration of the *Grade 6 Science Achievement Test* was the result of the concerted efforts of all involved. Success would have been impossible without substantial contributions from many people, particularly the students, teachers, and administrators who extended their full co-operation.

The technical expertise of Dr. T. O. Maguire, Professor, Division of Educational Research Services, University of Alberta, has been particularly valuable in this first application of the Achievement Testing Program. His contributions to the design, analysis, and reporting are gratefully acknowledged.

Lloyd E. Symyrozum
Director
Student Evaluation Branch

INTRODUCTION

This report presents the provincial results of the *Grade 6 Science Achievement Test* administered on June 8, 1982 as part of the Student Achievement Testing Program conducted by Alberta Education. The results are reported for 26 598 students in public and separate schools.

The report has an executive summary and three chapters. The executive summary contains a brief description of the Grade 6 science program and test and summarizes the results. Chapter I describes the Achievement Testing Program. Chapter II outlines the procedures followed in test development, describes the *Grade 6 Science Achievement Test*, and defines the sample. The results are presented in Chapter III with guidelines for interpretation.

EXECUTIVE SUMMARY

Findings

- The provincial average is 60.3% for knowledge and application of scientific process skills and subject matter.

- Students scored above the average in many of the specific scientific process skills, but scored below the average when required to combine several skills and apply them to novel situations.

- Students scored well below the average on a number of fundamental concepts in subject matter, particularly in the areas of *Matter and Energy* and *Earth-Space and Time*.

- Responses to the student attitude survey were generally positive.

- The results of the psychomotor skills questionnaire indicate that many students appear to have the opportunity to participate in "hands-on" activities in science. Equipment appears to be available to teachers, but no attempt was made to establish the quality or quantity of equipment.

What We Have Learned

- The results confirm the validity of the test, and indicate it has potential for continued use as a reliable measure of student achievement.

- Student achievement is low in parts of the curriculum dealing with higher intellectual skills and in the knowledge of some physical science concepts.

- The results appear to indicate that the students took the test seriously even though it did not affect their grades.

The Science Program

The *Grade 6 Science Achievement Testing Program* is designed to reflect the *Program of Studies* in elementary science as prescribed by the Minister of Education. The emphasis that each curricular area is to receive is as follows:

Scientific Process Skills - 50%
Subject Matter - 30%
Attitudes - 10%
Psychomotor Skills - 10%

Description of the Evaluation

Part A	Scientific Process Skills	36 questions	(60%)
	and Subject Matter	24 questions	(40%)
Part B	Attitude Survey	10 statements	
Part C	Psychomotor Skills	teacher questionnaire	

Results for Scientific Process Skills and Subject-Matter Test

- The provincial average for the total test is 60.3%.
- The average is 66.9% on the process skill questions and 50.9% on the subject-matter questions.
- For subject-matter topics, the average is 47.7% on *Matter and Energy*, 56.5% on *Living Things and the Environment*, and 44.4% on *Earth-Space and Time*.

Scientific Process Skills

- Students scored 72% or higher on seven questions related to measuring, classifying, experimenting, communicating, and using data presented in graphs and tables.

- Students scored 48% or lower on eight questions related to identifying the variable to be controlled in experimental situations, identifying the correct prediction, identifying the difference between inferences and observations, and defining operationally.

Subject Matter

- Students scored 72% or higher on two questions on subject matter. These were on the topics of adaptation and energy resources.

- Students scored 48% or lower on 13 questions on subject matter. These were on the topics of heat, light, electricity, ecosystems, environment, weather, and water and land.

Comparison with the 1978 MACOSA Results

In 1978, a similar achievement test was administered to Grade 6 science students. Sixteen questions from the 1978 test were included in the 1982 test to make it possible to compare results. The averages on these 16 questions are 68.8% and 66.9% for 1978 and 1982 respectively.

Results for Attitude Survey

Student response to the statements on the attitude survey was generally positive. The average percentage of students giving positive responses for each cluster of statements is as follows:

54.9% - awareness and appreciation of science and interest in science topics
72.9% - awareness and appreciation of safety in science
75.8% - awareness and appreciation of the environment and interest in conservation and the environment

Results for Psychomotor Skills Questionnaire

The percentage of teachers who indicated that their students had access to each piece of equipment is as follows:

99.9% - metre stick
92.3% - graduated cylinder or measuring cup
94.5% - thermometer
89.6% - hand lens
82.4% - balance
81.9% - microscope

Teachers gave the highest rating of student competence for the following skills:

- measuring distance to the nearest metre
- measuring distance to the nearest centimetre
- taking temperature to the nearest degree
- focusing a hand lens

Teachers gave the lowest rating of student competence for the following skills:

- measuring volume to the nearest millilitre
- preparing a slide
- constructing equipment
- calibrating equipment

Chapter I

THE ACHIEVEMENT TESTING PROGRAM

Purpose

The Achievement Testing Program is designed to provide data significant at both the local and provincial levels concerning student achievement in language arts, social studies, mathematics, and science for Grades 3, 6, 9, and 11. The purpose of the testing is to monitor the effectiveness of instructional programs by determining the extent to which curricular objectives are being achieved. Since averages are reported for a number of specific topics and skills within each subject area, strengths and weaknesses across the province and within each jurisdiction can be identified. The results provide provincial standards and benchmarks that will serve as a basis for the long-term appraisal of student achievement. These standards will help jurisdictions to evaluate the effectiveness of their local programs.

1982 Tests

Each test is specific to the provincial *Program of Studies* prescribed by the Minister of Education for the subject and grade being tested. Only one subject at any grade level is tested in a given year. The full program of testing is accomplished within a four-year cycle. In 1982, tests were given in Grade 3 mathematics, Grade 6 science, English 30, and English 33. A test for

Grade 9 social studies was scheduled, but it was postponed because the new curriculum had not been fully implemented across the province. Commencing in the 1983-84 school year, achievement testing at the Grade 12 level will be replaced by testing in Grade 11.

The results are reported in the fall term following the testing in June. A summary report is prepared for public distribution, and a more comprehensive report is issued to jurisdictions. Each jurisdiction receives summary tables for that jurisdiction and for each school as well as student scores. Individual statements of results are not issued to students by Alberta Education.

Exemptions from Testing

Under normal circumstances, the following classes are exempt from achievement testing:

- Special Education Classes registered for grants with the Special Educational Services Branch
- classes in which the language of instruction is other than English, under the terms of Section 159 of the *School Act*
- classes in which the subject being tested has been cycled and taught in an alternate year
- classes in which the subject has been taught in a semester other than that in which the test is being administered
- classes for students for whom English is a second language

Chapter II

DESCRIPTION OF TEST AND SAMPLE

This chapter has three main sections. The first section outlines the procedures that were followed during test development, the second section provides a description of the test, and the third section describes the student sample that was tested.

Test Development

There were three stages in the development of the *Grade 6 Science Achievement Test*: preparation of curriculum specifications, development of questions, and selection of questions for the final copy.

1. Curriculum Specifications

   The Curriculum Branch prepared curriculum specifications based on the provincial *Program of Studies*. In the specifications, weightings were assigned to each major content area and to specific topics outlined in the *Program of Studies*. These weightings identified the emphasis that each topic was to receive in the program. The curriculum specifications were distributed to all school jurisdictions in the province and minor revisions were made on the basis of the feedback that was received. Topic statements from the curriculum specifications upon which specific questions were based are listed under each content area with the results in Chapter III.

2. Development of Questions

A committee composed of teachers and Student Evaluation Branch personnel constructed questions to reflect the topic statements listed in the curriculum specifications. After careful review, questions were also selected from existing tests and item banks. Another teacher committee examined the questions for content validity and revisions were made based on teacher recommendations and field-test results.

3. Final Copy

A test was constructed from those questions that were approved by the teacher committees. Questions were selected from the various content areas so that each area received the emphasis that was recommended in the curriculum specifications. This version of the test was examined by a Technical Review Committee for content validity, accuracy, and technical merit. Additional changes were made to meet their recommendations, and the final copy was printed.

Test Description

The *Grade 6 Science Achievement Testing Program* is designed to reflect the following curricular emphases as recommended for science in the provincial *Program of Studies*:

Scientific Process Skills	- 50%
Subject Matter	- 30%
Attitudes	- 10%
Psychomotor Skills	- 10%

The Grade 6 testing program has three components. Part A is a 60-item multiple-choice test of scientific process skills and subject matter. Part B is a 10-item attitude survey designed to measure awareness of, appreciation of, and interest in science and current science issues. Part C is a teacher questionnaire on availability of equipment and student competence in psychomotor skills.

Part A - Scientific Process Skills and Subject Matter

Part A contains 36 questions on *Scientific Process Skills* and 24 questions on the topics of *Matter and Energy*, *Living Things and the Environment*, and *Earth-Space and Time*. Students are allowed 60 minutes to write the test. Elective portions of the curriculum are not covered by the test. The test measures student knowledge and comprehension of facts, concepts, and processes, and students' ability to apply knowledge and skills. Knowledge and comprehension questions require recognition and basic understanding of facts and concepts. Application questions require students to solve problems and to use concepts and skills in new situations. The distribution of questions is presented in Table 1.

Table 1

Test Question Distribution for Part A

Content Area	Emphasis	Number of Questions: Knowledge and Comprehension	Application	Total
Matter and Energy	17%	5	5	10
Living Things and the Environment	17%	4	6	10
Earth-Space and Time	7%	2	2	4
Scientific Process Skills	60%	4	32*	36

* Six of these questions require an integration of subject-matter knowledge with scientific process skills.

The specific topics tested within each content area and sample questions are included with the results in Chapter III.

Part B - Attitudes

Students indicate agreement or disagreement with 10 opinion statements related to science and current science issues. Four statements are related to conservation and the environment, four are related to science as a field of study and to the impact of science on mankind, and two are related to laboratory safety. The six response alternatives are: strongly agree, agree, undecided, disagree, strongly disagree, and do not care. Each statement is reproduced with the student responses in Chapter III.

Part C - Psychomotor Skills

Part C is a teacher questionnaire containing a checklist to identify equipment to which students have had access and a set of questions about student competence in carrying out selected laboratory tasks. The complete questionnaire is reproduced along with the teacher responses in the Appendix.

Sample

A total of 26 598 students representing 865 public and separate schools and 611 students representing 56 private schools were tested. Students from private schools are not included in the results presented in Chapter III.

Psychomotor skills questionnaires were sent to each teacher who had a science class that was tested. Completed questionnaires were returned by 1080 teachers in public schools and 53 teachers in private schools.

Each school jurisdiction was given the option of either testing all Grade 6 students or testing randomly selected classes. To ensure a minimal sampling error for jurisdiction results, however, it was necessary to test almost all of the classes in small jurisdictions. Since there was little practical benefit from sampling in small jurisdictions, they all chose to test all classes. Only two jurisdictions opted for sampling, which was done by class unit. Complete lists of classes for these jurisdictions were obtained and random samples were selected, consisting of 46% of the Grade 6 classes from one jurisdiction and 45% of the Grade 6 classes from the other jurisdiction.

The standard errors due to sampling are less than 0.01% for all provincial averages and less than 0.1% for the two jurisdictions in which sampling was used.

Chapter III

RESULTS

Results are reported for the 26 598 student test booklets and 1080 teacher questionnaires that were received from public and separate schools. In computing provincial averages and percentages, the results from the two jurisdictions that used sampling were weighted because only about half of the students in these districts were selected for testing.

Guidelines for Interpretation of Results

Many factors influence the performance of students within jurisdictions, which makes setting standards a difficult task. Some of these factors are listed below.

1. The tests were designed to sample the Grade 6 science curriculum, but the amount of instruction given on each topic may vary from one class to another.

2. Any time a test is used to measure achievement, there are minor variations in the results due to factors such as guessing, clerical errors, and errors due to lapses of attention.

3. The size of jurisdiction may influence the results in any particular year, since the average level of aptitude is more likely to fluctuate in smaller jurisdictions than in larger ones.

4. Longer subtests are more reliable than shorter subtests in their estimation of average achievement.

5. The tests are necessarily paper-and-pencil representations of the skills developed in science.

6. Elective portions of the curriculum were not covered by the test.

In view of these factors, it was decided that an average of 60% would be a reasonable target for subtest and total test scores. Since the jurisdiction averages are subject to the influences mentioned earlier, target regions have been set up to aid in test interpretation. For *Total Test*, *Scientific Process Skills*, and *Subject Matter*, the regions were set at two percentage points around the target. For the shorter subtests, the regions were set at five points around the target. Jurisdictions with fewer than 100 students writing should use differences of five and ten points to identify areas of strength and weakness. The target regions are given below.

Subtest	Number of Questions	Target Regions (%) <100 Students	Target Regions (%) >100 Students
Total Test	59	55 - 65	58 - 62
Scientific Process Skills	35	55 - 65	58 - 62
Subject Matter	24	55 - 65	58 - 62
Matter and Energy	10	50 - 70	55 - 65
Living Things and the Environment	10	50 - 70	55 - 65
Earth-Space and Time	4	50 - 70	55 - 65

To interpret results for a jurisdiction, the reader should first read the sample questions, examine the test specifications, and decide whether the target levels are appropriate for that jurisdiction. Next, the jurisdiction averages should be compared with the target values and those outside the target regions noted. While there is a tendency for people to focus on areas that are below the target level, some pride should be taken in those areas that fall above the target region.

It must be emphasized that the purpose of the Achievement Testing Program is to produce results valid at the jurisdictional and provincial levels, not at the individual class or student level. Because of restrictions of time and space, the test questions are only a small sample of possible questions for any curricular objective. Thus, individual student scores may vary greatly, depending on the specific questions selected. Accordingly, the achievement tests were not designed to evaluate individual students, but rather to evaluate the performance of programs within a jurisdiction or within the province. Conclusions about the performance of any given class should not be made either. Most classes have a small number of students and there is a large variation in the average ability of students in different classes.

For large groups of students, variations due to question selection will average out. If the numbers are sufficient, it is meaningful to compare the achievement of groups of students with the provincial averages. Jurisdictional results are presented in tables that parallel the tables of provincial results to facilitate comparisons.

Since standard errors due to sampling are less than 0.1%, any difference between a jurisdictional average and a provincial average is statistically significant. Whether the difference is educationally meaningful is a question that must be addressed by each jurisdiction. Again, the two- and five-point guidelines are useful for the larger jurisdictions and the five- and ten-point guidelines can be used by jurisdictions with fewer than 100 students. Jurisdictions with fewer than 25 students should exercise caution when comparing results with provincial averages.

When examining the results of the achievement tests, readers should keep in mind that a test score cannot reveal why a performance occurred, only that it did occur. After areas of strength and weakness have been determined, the difficult task of identifying the reasons for these strengths and weaknesses should be undertaken. A variety of factors should be examined.

1. Student motivation. Were students motivated to take the test?
2. Student ability. A group of students with a particularly high or low ability level may have been tested. This is much more likely to occur in small systems than in large ones.
3. Teaching curriculum. Since much care was taken in designing the test to fit the Alberta curriculum, areas of weakness may be the result of discrepancies between provincial and local programs.

There will, of course, be other factors that are of importance in particular jurisdictions. Jurisdictions are encouraged to establish local interpretation panels to examine the results in light of local factors.

Absentees

If more than 10% of the eligible students in a jurisdiction did not write the test, the reported averages for that jurisdiction may not accurately represent the true jurisdiction averages. Teacher-assigned marks for students who did not write could be compared with teacher-assigned marks for students who did write. If the averages are the same for the two groups, the reported jurisdiction averages are probably representative. If the averages are different, some estimates can be made of what the jurisdiction averages might have been if all students had written the test. Jurisdictions with high absentee rates may wish to contact the Student Evaluation Branch for assistance in estimating their jurisdiction averages.

Cautions

The following cautions should be observed when examining the results for the *Grade 6 Science Achievement Test*.

1. The findings are limited to those that can be obtained from a pencil-and-paper test; many skills developed in science cannot be measured by this type of test.

2. The questions on the test cover a representative sample of the objectives in the science curriculum. They do not cover every objective.

3. Some of the subtests have only one or two items. Caution must be exercised when comparing achievement levels among the subtests. It was not possible to ensure that each topic was tested by questions of comparable difficulty.

4. The test is based on the priorities prescribed by the provincial *Program of Studies*. It was not possible to reflect each local jurisdiction's unique interpretation of the program.

Part A - Scientific Process Skills and Subject Matter

Over 99% of the students completed the test, indicating that sufficient time was allowed.

The questions in Part A have been grouped according to content area and cognitive level to produce subtests. The three subtests on subject matter were generated by combining questions on *Matter and Energy*, *Living Things and the Environment*, and *Earth-Space and Time*. Provincial averages in per cent are reported in Table 2 for 15 subtests and the total test. The number of questions on each subtest is also given.

Table 2

Provincial Averages for Subtests in Part A

Subtest	Number of Questions	Average Percentage
Matter and Energy (Knowledge)	5	51.3
Matter and Energy (Application)	5	44.1
Matter and Energy (Total)	10	47.7
Living Things and the Environment (Knowledge)	4	66.3
Living Things and the Environment (Application)	6	49.9
Living Things and the Environment (Total)	10	56.5
Earth-Space and Time (Knowledge)	2	55.1
Earth-Space and Time (Application)	2	33.7
Earth-Space and Time (Total)	4	44.4
Subject Matter (Knowledge)	11	57.5
Subject Matter (Application)	13	45.2
Subject Matter (Total)	24	50.9
Scientific Process Skills (Knowledge)	4	88.5
Scientific Process Skills (Application)	31	64.1
Scientific Process Skills (Total)	35	66.9
Total Test	59*	60.3

* The test that was administered has 60 questions, but one question on Scientific Process Skills (Application) was omitted from the analyses because the diagram was ambiguous.

The standard deviation for the total test is 12.5%. The average for the total test is very close to the target of 60%. The average for *Scientific Process Skills* is above the upper limit of the target region as outlined on page 10. The averages for *Matter and Energy*, *Earth-Space and Time*, and *Subject Matter* are below the lower limits of the target regions.

The results for selected subtests are presented graphically in Figures 1 and 2. The achievement levels for *Scientific Process Skills (Total)*, *Subject Matter (Total)*, and *Total Test* are presented in Figure 1. Figure 2 shows the achievement levels for *Matter and Energy (Total)*, *Living Things and the Environment (Total)*, and *Earth-Space and Time (Total)*.

The average for *Scientific Process Skills* is higher than the average for *Subject Matter*. Within the three content areas grouped under *Subject Matter*, the average for *Living Things and the Environment* is higher than the averages for *Matter and Energy* and *Earth-Space and Time*. Within each content area, averages on the knowledge and comprehension subtests are higher than the averages for the application subtests.

The results for each content area are discussed in detail in the following sections. The topics that were tested within each content area are listed and sample questions from the test are provided. An asterisk is placed beside the letter corresponding to the correct response for each question, and the percentage of students selecting each response is given. Areas of high and low achievement are identified.

Figure 1

Averages for Total Test,
Scientific Process Skills, and Subject Matter

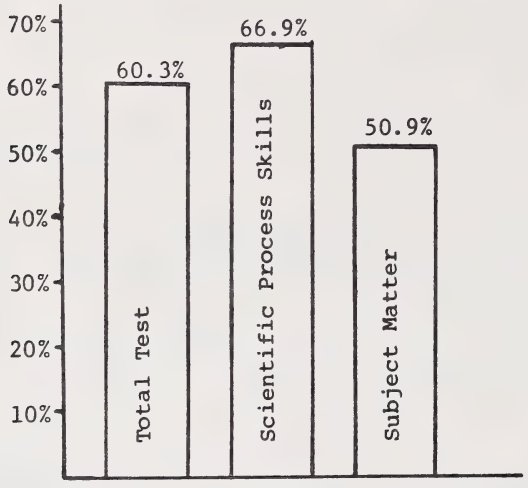
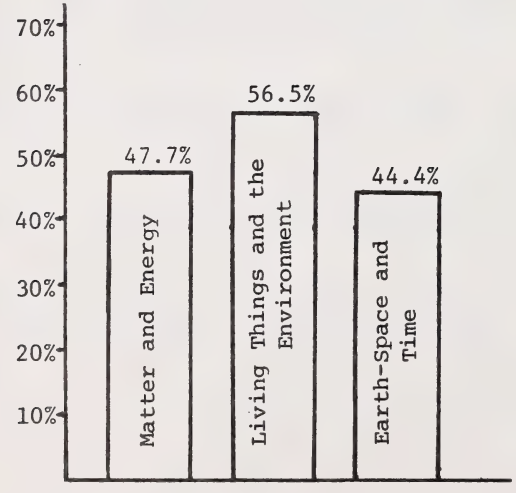


Figure 2

Averages for Subject-Matter Content Areas



Matter and Energy

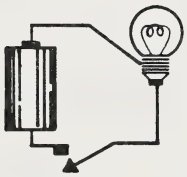
Questions in this content area cover the topics of energy resources and conservation, electricity, light, heat, sound, magnetism, and changes in matter. Questions are related to the following topic statements:

- Energy exists in many forms.
- An object that has an electrical charge can attract or repel another charged object.
- Simple electrical circuits can be constructed using a bulb, wire, and cell.
- White light is a combination of light of all the colors of the spectrum.
- A beam of light can be reflected or refracted.
- Chemical changes produce new materials with different properties. Some chemical changes can be reversed, but most are difficult to reverse.
- Heat gain or heat loss can be indicated by using a thermometer.
- Solids generally conduct sound better than liquids or gases.
- When an electrical current passes through a coiled wire, it produces an electromagnet.

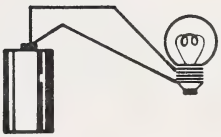
Example 1: Electricity; Application

The circuit in which the bulb is lit is

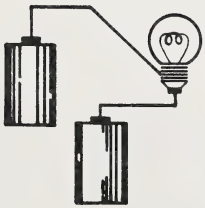
11.1% A.



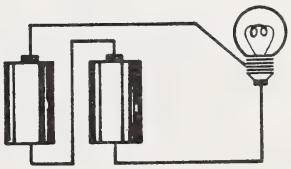
13.0% B.



16.7% C.

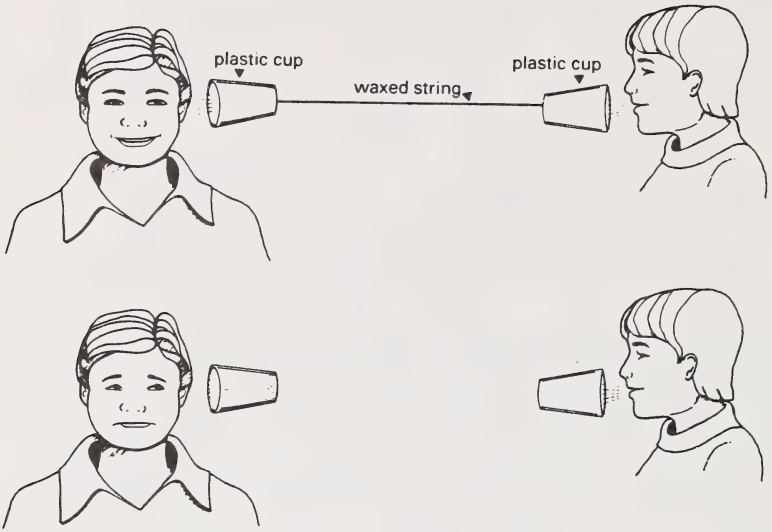


59.1% *D.



0.2% no response

Example 2: Sound; Knowledge



Two students made their own telephone system using plastic cups and string. When they held the cups so the string was tight, one could hear the other, but when the string was removed, they could hear no sound. The most likely explanation is that

3.4%	A.	the students were too far away from each other
25.4%	B.	air particles do not vibrate fast enough to carry sound
50.4%	*C.	sound travels better through solids than through air
20.6%	D.	the cup bottoms vibrate less when the string is attached
0.3%		no response

The average for *Matter and Energy* is 47.7%. The highest levels of achievement are on the topics of energy resources and magnetism, with averages of 71.2% and 69.4%, respectively. The lowest levels of achievement are on the topics of electricity, light, changes in matter, and heat, which all have averages below 40%. The test contains only one to three questions on all of these topics.

Living Things and the Environment

Questions in this content area cover the topics of ecosystems, adaptation, environment, and environmental factors. Questions are related to the following topic statements:

- Food is cycled within an environment (producer, consumer, decomposer).
- The living and nonliving parts of an environment make up an ecosystem.
- Some animals interact in a predator-prey relationship.
- Structural and behavioral adaptations enable organisms to survive in their environment.
- Camouflage is one kind of adaptation.
- Man's influence on the environment has been positive and negative.
- Organisms live in habitats that have factors favorable to their survival.

Example 1: Adaptation; Knowledge

A snowshoe hare has large, fur-covered hind feet to help it move more easily over snow. Another adaptation that helps the hare to survive in winter is that it

2.3%	A.	eats only during the warmest part of the day
11.5%	B.	increases its running speed to escape from enemies
8.9%	C.	has a coat that stays grey-brown to absorb as much heat as possible
77.2%	*D.	has a coat that turns white to provide camouflage
0.1%		no response

Example 2: Environmental Factors; Application

In a study with isopods (small bugs), a class found that isopods prefer the following:

a temperature range of 5°C - 12°C
darkness rather than light
moist places rather than dry places

Where would you expect to find an isopod in the environment?

77.4%	*A.	under a log
8.8%	B.	on the leaves of a tree
5.1%	C.	on top of a rock
7.9%	D.	in a dry grassy area
0.8%		no response

The average for *Living Things and the Environment* is 56.5%. The highest level of achievement is on the topic of adaptation, with an average of 79.3%. The lowest levels of achievement are on the topics of environment and ecosystems, with averages of 44.5% and 39.9% respectively. The test contains only two or three questions on each of these topics.

Earth-Space and Time

Questions in this content area cover the topics of weather and water and land. Questions are related to the following topic statements:

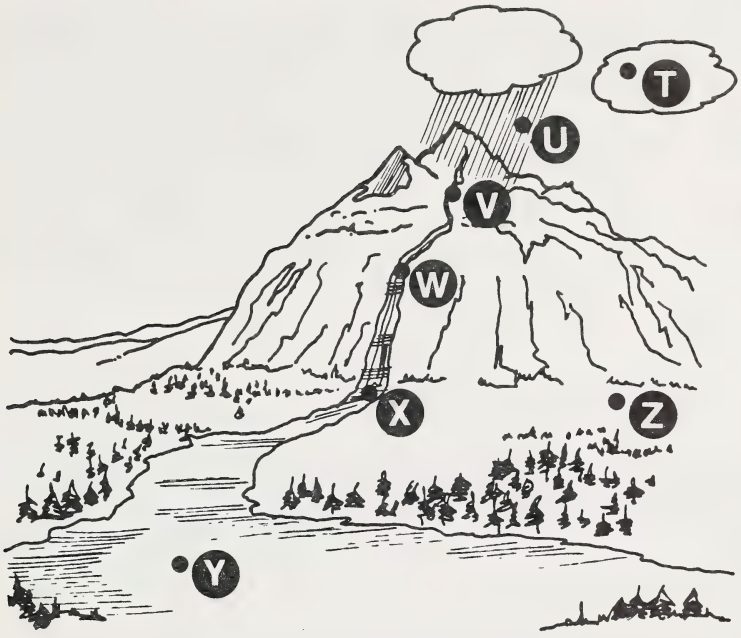
- Wind is caused by the movement of air masses.
- Moving water erodes and changes the land over time.
- Many geological formations are a result of the force of moving water.
- The water cycle plays an important role in maintaining the earth's surface water.

Example 1: Water and Land; Knowledge

The hoodoos in this picture were probably formed by the action of

7.1%	A.	wind only
4.2%	B.	rain only
69.2%	*C.	wind and rain
18.4%	D.	wind and the sun
1.0%		no response

Example 2: Water and Land; Application



The greatest deposit of sediment will occur at the point marked with the letter

20.1%	A.	V
14.2%	B.	W
28.2%	C.	X
36.5%	*D.	Y
1.1%		no response

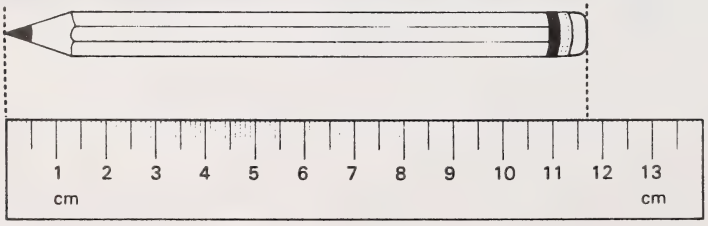
The average for *Earth-Space and Time* is 44.4%. The average for the question on weather is 42.7%. The average for the three questions on water and land is 46.2%.

Scientific Process Skills

The process skills measured by questions in this content area are communicating, observing, measuring, classifying, inferring, predicting, controlling variables, interpreting data, experimenting, hypothesizing, and defining terms operationally. The questions measure ability to:

- extend sophistication in graphing to include histograms, use of co-ordinate systems, and circle graphs
- record responses by using simple symbols
- distinguish between observations and inferences
- select appropriate units of measurement
- use simple instruments for measurement
- identify the condition or basis of a given classification set
- identify, through deductive thinking, an unidentified object in a classification scheme, given various classification conditions
- classify objects according to attributes or properties
- apply the inferring process to situations which require direct observation
- test the results of a prediction
- make predictions from recorded data
- state predictions based on past experience
- identify variables that might influence a phenomenon that is being investigated
- identify which variables should be kept the same and which variables should be changed in an investigation
- design simple investigations in which one variable is changed and all others are kept the same
- identify patterns in data
- extract useful information
- generalize from patterns in data
- apply problem-solving skills to an identified problem
- construct testable hypotheses
- identify an operational definition from a list

Example 1: Measuring; Knowledge

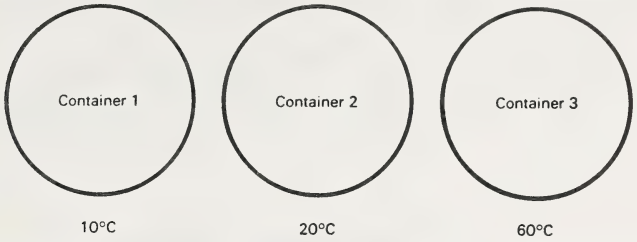


The length of the pencil is

14.2%	A.	113 mm
4.9%	B.	116 mm
71.9%	*C.	117 mm
8.9%	D.	118 mm
0.2%		no response

Example 2: Hypothesizing; Application

Sarah did an experiment on the growth of bread mold. She grew mold in three containers. One container was kept at 10°C, one was kept at 20°C, and one was kept at 60°C. She recorded the amount of bread mold in each container at the end of four days.

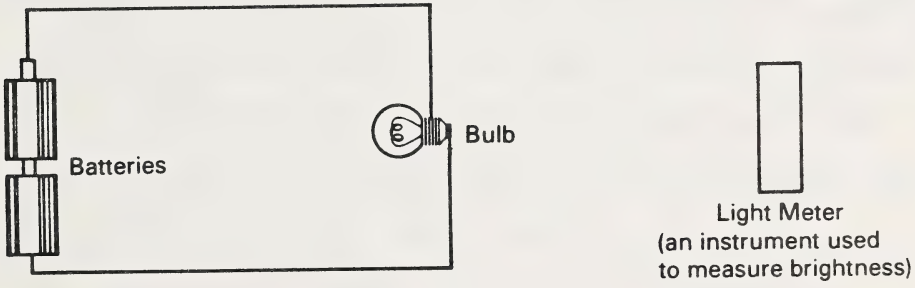


Choose the hypothesis that Sarah could have been testing.

66.1% *A. The amount of bread mold depends on the temperature.
4.2% B. The amount of bread mold depends on the number of containers.
7.4% C. The amount of bread mold depends on the amount of nutrients.
22.0% D. The amount of bread mold depends on the number of days.
0.2% no response

Example 3: Controlling Variables; Application

A student wanted to test the hypothesis that the brightness of light depends upon the number of flashlight batteries in the circuit. The following apparatus was used.



To test this hypothesis, which one of the following should the student change in this experiment?

32.1% *A. the number of flashlight batteries
8.9% B. the number of light bulbs
39.6% C. the distance from the light bulb to the light meter
19.1% D. the size of the flashlight batteries
0.2% no response

Example 4: Defining Terms Operationally; Application

A moose is a consumer because it eats plants. A wolf is a consumer because it eats rabbits, mice, and other small animals. A bear is a consumer because it eats both plants and animals. Choose the definition that best describes a consumer.

6.3%	A.	A consumer is an organism that lives on the remains of dead plants and animals.
26.4%	B.	A consumer is an organism that eats both plants and animals.
23.1%	C.	A consumer is an organism that hunts or searches for its food.
44.0%	*D.	A consumer is an organism that depends upon other organisms for its food supply.
0.1%		no response

The average for *Scientific Process Skills* is 66.9%. The highest levels of achievement are on measuring, classifying, interpreting data, and communicating, with averages of 88.6%, 85.7%, 78.3%, and 76.5% respectively. The four questions on measuring make up the knowledge and comprehension subtest. The lowest levels of achievement are on controlling variables and defining terms operationally, with averages of 47.6% and 44.2% respectively. Only 42% of the students were able to distinguish inferences from observations.

In summary, the average for *Scientific Process Skills* is higher than the average for *Subject Matter*. Within the three content areas grouped under *Subject Matter*, the average for *Living Things and the Environment* is higher than the averages for *Matter and Energy* and *Earth-Space and Time*.

The averages are considerably above the test average for the following skills and topics:

- measuring
- classifying
- communicating
- interpreting data
- adaptation
- energy resources
- magnetism

The averages are considerably below the test average for the following skills and topics:

- controlling variables
- defining terms operationally
- environment
- ecosystems
- electricity
- light
- heat
- changes in matter
- weather
- water and land

Comparison with the 1978 MACOSA Results

In 1978, a similar achievement test was administered to Grade 6 science students. Sixteen questions from the 1978 test were included in the 1982 test to make it possible to compare results. Since many of the questions were modified considerably, a detailed comparison within content areas is not justified. The averages on these 16 questions are 68.8% and 66.9% for 1978 and 1982 respectively, indicating a similar level of achievement.

Part B - Attitudes

The percentage of students selecting each response for each statement in Part B is given in Table 3.

Table 3

Student Responses to Part B

Statement	Percentage of Students						
	* SA	A	U	D	SD	DC	NR
I like to read and learn about things that involve science.	11.6	48.9	16.3	13.3	3.9	5.8	0.3
I can use skills and ideas that I learn in science to solve problems in my life.	15.7	43.7	21.9	12.4	3.1	2.8	0.4
Scientists have created more problems than they have solved.	9.6	14.8	20.9	31.3	18.0	4.8	0.6
Ideas from science are too difficult for ordinary people to understand.	8.3	18.6	18.4	35.1	14.9	4.1	0.6
Accidents can be prevented if instructions are followed when working with science material.	42.5	31.9	10.9	7.2	3.7	3.3	0.5
It is necessary for students to wear safety glasses when heating powder in a test tube.	39.8	31.6	15.8	5.5	2.2	4.5	0.6
Saving paper, bottles, and cans for recycling is not worth the time and effort it takes.	5.6	9.5	10.7	27.2	38.8	7.6	0.5
If pollution of the environment continues to increase, then I should be concerned that many living things will die.	50.7	29.5	10.8	3.5	2.3	2.6	0.6
We should use as much energy as we need to make our lives more comfortable, even if others have to go without.	5.2	9.5	11.7	22.7	47.0	3.4	0.4
I enjoy watching wild animals in their natural environment.	61.3	26.4	4.6	1.4	1.2	4.8	0.3

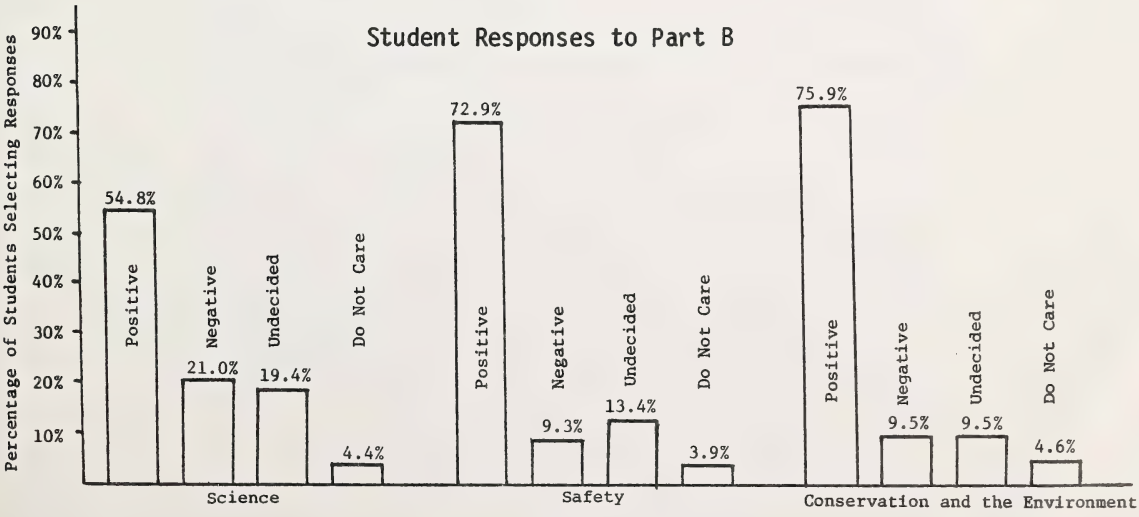
* SA - strongly agree
A - agree
U - undecided
D - disagree
SD- strongly disagree
DC - do not care
NR - no response

The student responses were generally positive. More than 80% of the students expressed a concern for and enjoyment of living things; more than 70% showed an awareness of the need for safety precautions in the laboratory; more than 65% supported conservation measures; more than 60% expressed an interest in science; and 50% indicated that they felt that ordinary people could understand science and that scientists have solved more problems than they have created. The percentage of students selecting the do not care alternative ranged from 2.6 on concern for the danger to living things from pollution to 7.6 on saving paper, bottles, and cans for recycling. The percentage of students selecting the undecided alternative ranged from 4.6 on enjoyment from watching wild animals to 22.7 on energy consumption.

The responses to Part B are summarized in Figure 3. Strong agreement and agreement with a positively worded statement were combined with strong disagreement and disagreement with a negatively worded statement to get the percentage of students giving a positive response. The opposites of these responses were combined for the negative response. The first four statements are related to science, the fifth and sixth statements are related to safety, and the last four statements are related to conservation and the environment.

Figure 3

Student Responses to Part B



Part C - Psychomotor Skills

The teacher questionnaire on psychomotor skills is reproduced in the Appendix with the results. The responses for the section on availability of equipment are summarized in Table 4, which gives the percentage of teachers who indicated that each piece of equipment was available to their students. The questionnaire did not address questions pertaining to the condition or quantity of equipment. Some teachers indicated that their equipment was in poor condition or that limited numbers were available. Some teachers also indicated that equipment had to be borrowed from resource centres and other schools.

Table 4

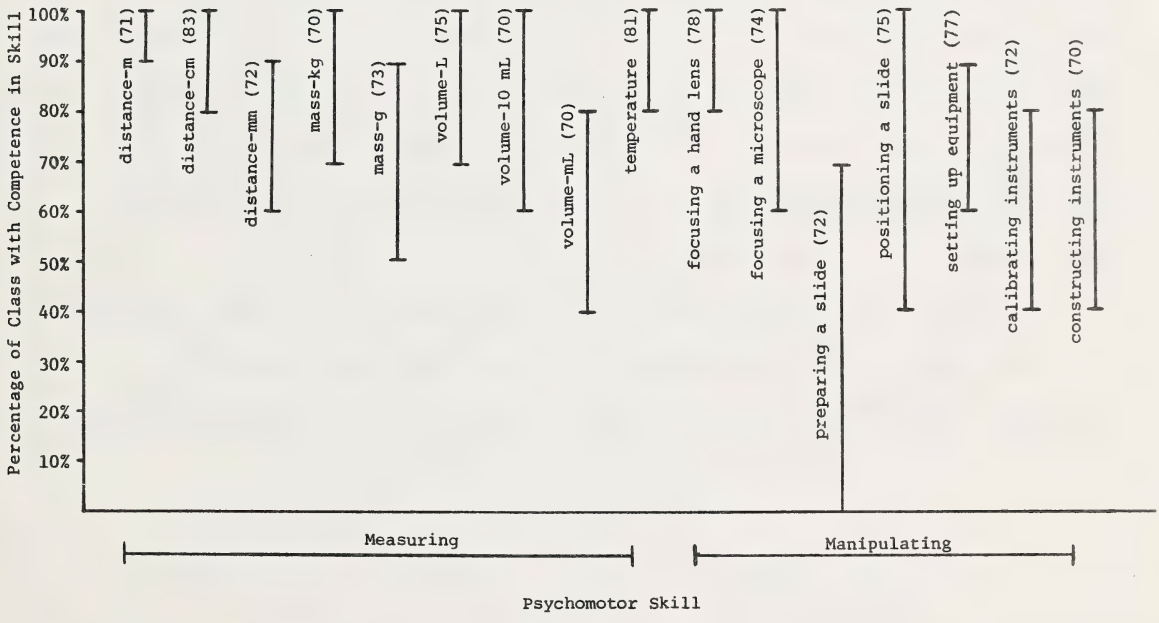
Availability of Equipment

Equipment	Availability (%)
Metre stick	99.9
Graduated cylinder, measuring cup, etc.	92.3
Thermometer	94.5
Hand lens	89.6
Balance	82.4
Microscope	81.9

The responses to the section on student competence in performing tasks are summarized in Figure 4. The graph shows the interval that includes at least 70% of the teacher responses for each task. The numbers in parentheses specify the percentage of teacher responses contained in each interval. For example, 71% of the teachers indicated that all of their students or 90% of their students can measure distance to the nearest metre.

Figure 4

Intervals Containing at Least 70% of the Teacher Responses



Teachers gave the highest rating of student competence for the following skills:

- measuring distance to the nearest metre
- measuring distance to the nearest centimetre
- taking temperature to the nearest degree
- focusing a hand lens

Teachers gave the lowest rating of student competence for the following skills:

- measuring volume to the nearest millilitre
- preparing a slide
- constructing instruments
- calibrating instruments

Concluding Observations

The provincial average for the total score in Part A is very close to the target identified under guidelines for the interpretation of results. *Scientific Process Skills* is the only content area for which the average is higher than the upper limit of the target region. The average for *Living Things and the Environment* is within the target region. The averages for *Matter and Energy*, *Earth-Space and Time*, and *Subject Matter* are below the lower limits of the target regions.

The responses to the attitude survey were generally positive. The results of the psychomotor skills questionnaire indicate that many students are receiving the opportunity to participate in "hands-on" activities in science. Target regions were not established for these two components.

Appendix

PSYCHOMOTOR SKILLS QUESTIONNAIRE

The teacher questionnaire on psychomotor skills is reproduced with the results in Table 5. The average number of students upon which the responses were based is given. For the remainder of the questionnaire, the percentage of teachers selecting each response is given. A no response (NR) category has been added for this report.

Table 5

Psychomotor Skills Questionnaire

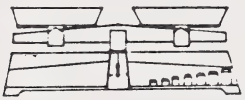
Number of students in your Grade 6 science class(es) upon which responses to this questionnaire are based: average = 25.9 NR = 43.2%

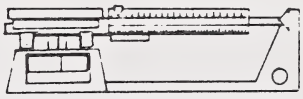
Question 1: Equipment

Please check (✓) those pieces of equipment that are available to your Grade 6 students.

		Available? YES	NO	NR
a)	Metre stick	99.9	0.1	0.0
b)	Graduated cylinder, measuring cup, etc.	92.3	6.7	1.1
c)	Thermometer	94.8	4.4	0.8
d)	Hand lens	89.5	8.8	1.6
e)	Balance	82.2	17.0	0.8

If your answer to e) is yes, please check (✓) the type of balance(s) used.

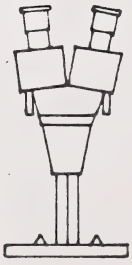




(i) equal arm 68.2 (ii) triple beam 27.1 (iii) other 8.1 NR 0.8

		YES	NO	NR
f)	Microscope	81.8	16.5	1.7

If your answer to f) is yes, please check (✓) the type of microscope(s) used.



(i) monocular 75.6 (ii) binocular 17.5 (iii) other 2.4 NR 1.7

Continued on next page

Table 5 - Continued

Question 2: Measurement Motor Skills

Please check (✓) the space indicating the **percentage** (to the nearest 10) of your class(es) that is able to measure

a) distance to the nearest metre

0.0	0.2	0.5	0.3	1.0	0.8	3.0	4.1	17.7	21.4	49.7	1.5
0		20		40		60		80		100	NR

b) distance to the nearest centimetre

0.3	0.3	0.8	0.3	1.0	2.1	4.8	6.5	25.5	23.9	33.3	1.2
0		20		40		60		80		100	NR

c) distance to the nearest millimetre

0.8	0.6	2.7	0.9	3.2	5.8	15.9	14.9	24.9	16.0	13.0	1.2
0		20		40		60		80		100	NR

d) mass to the nearest kilogram

2.0	0.6	2.0	0.8	3.9	6.8	12.2	7.9	24.0	15.5	22.2	2.2
0		20		40		60		80		100	NR

e) mass to the nearest gram

2.4	1.6	3.4	1.9	7.4	9.5	16.1	12.8	22.5	12.2	7.4	2.9
0		20		40		60		80		100	NR

f) volume of liquids to the nearest litre

1.0	0.5	1.6	0.7	3.6	4.1	12.3	8.4	22.2	16.5	27.4	1.7
0		20		40		60		80		100	NR

g) volume of liquids to the nearest 10 millilitres

2.2	1.8	4.0	2.4	8.2	9.3	16.2	12.4	22.7	9.6	9.1	2.0
0		20		40		60		80		100	NR

h) volume of liquids to the nearest millilitre

3.6	2.8	7.2	2.7	10.5	11.5	17.2	13.1	17.5	7.8	4.3	1.8
0		20		40		60		80		100	NR

i) temperature to the nearest degree

0.6	0.3	0.5	0.2	0.9	1.2	6.1	8.1	22.4	24.3	34.2	1.2
0		20		40		60		80		100	NR

Continued on next page

Table 5 - Continued

Question 3: Facility with Fine Motor Skills

Please check (✓) the space indicating the **percentage** (to the nearest 10) of your class(es) that is able to

a) focus a hand lens

0	2.3	0.4	20	1.4	0.4	40	1.7	1.6	60	7.1	4.8	80	15.2	16.8	100	45.9	2.5	NR

b) focus a microscope

0	5.0	1.9	20	3.7	1.1	40	4.7	5.4	60	14.8	9.8	80	21.4	15.2	100	13.0	4.1	NR

c) prepare a slide

0	13.0	5.7	20	9.4	4.4	40	8.6	9.4	60	13.4	8.5	80	11.2	6.3	100	4.8	5.3	NR

d) position a slide properly under a microscope

0	8.0	3.3	20	6.8	3.0	40	7.6	8.4	60	12.2	10.0	80	17.8	10.6	100	7.9	4.5	NR

Question 4: Assembly Motor Skills

Please check (✓) the space indicating the **percentage** (to the nearest 10) of your class(es) that is able to

a) set up equipment according to instructions

0	1.0	1.0	20	1.8	1.2	40	5.6	7.6	60	19.0	18.6	80	27.9	11.3	100	4.0	1.3	NR

Continued on next page

Table 5 - Continued

Question 5: Calibration and Construction Motor Skills

Please check (✓) the space indicating the **percentage** (to the nearest 10) of your class(es) that is able to

a) calibrate an unmarked instrument, such as an unmarked metre stick, beaker, thermometer, etc.

3.8	4.9	8.3	4.2	13.1	14.8	20.3	13.0	10.8	2.9	1.8	2.4
0		20		40		60		80		100	NR

b) construct usable simple instruments, such as a rain gauge, clinometer, pinhole camera, etc.

4.2	4.5	7.1	4.2	11.1	11.5	19.2	14.6	13.4	5.5	2.7	2.0
0		20		40		60		80		100	NR